Evaluation of Chinook Salmon Facility Losses at the Tracy Fish Collection Facility

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Summary

Reclamation's Tracy Fish Collection Facility (TFCF) located in the southern Sacramento-San Joaquin Delta (Delta) was designed to divert juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and striped bass (*Morone saxatilis*) from Delta Mendota Canal (DMC) flows, thereby preventing entrainment loss to the downstream Jones Pumping Plant (JPP, Central Valley Project; Bates *et al*. 1960; Figure 1). Fish entrainment is defined as "the incidental trapping of any life stage of fish within waterways or structures that carry water being diverted for anthropogenic use" (NMFS 2010). The TFCF uses a louver-bypass system to intercept and guide fish from DMC entrainment into collection tanks where they are held until they are truck-transported back to the Delta and away from the immediate influence of the JPP (Figure 1). Fish and exported flows enter the facility underneath a surface debris collector (trash boom), through a trashrack with 5.1-cm (2.0-in) wide bar spacing and the 25.6-m (84-ft) wide primary channel to one of four bypass entrances along the louver wall. Once inside a bypass entrance, fish move into underground concrete pipes to the secondary channel

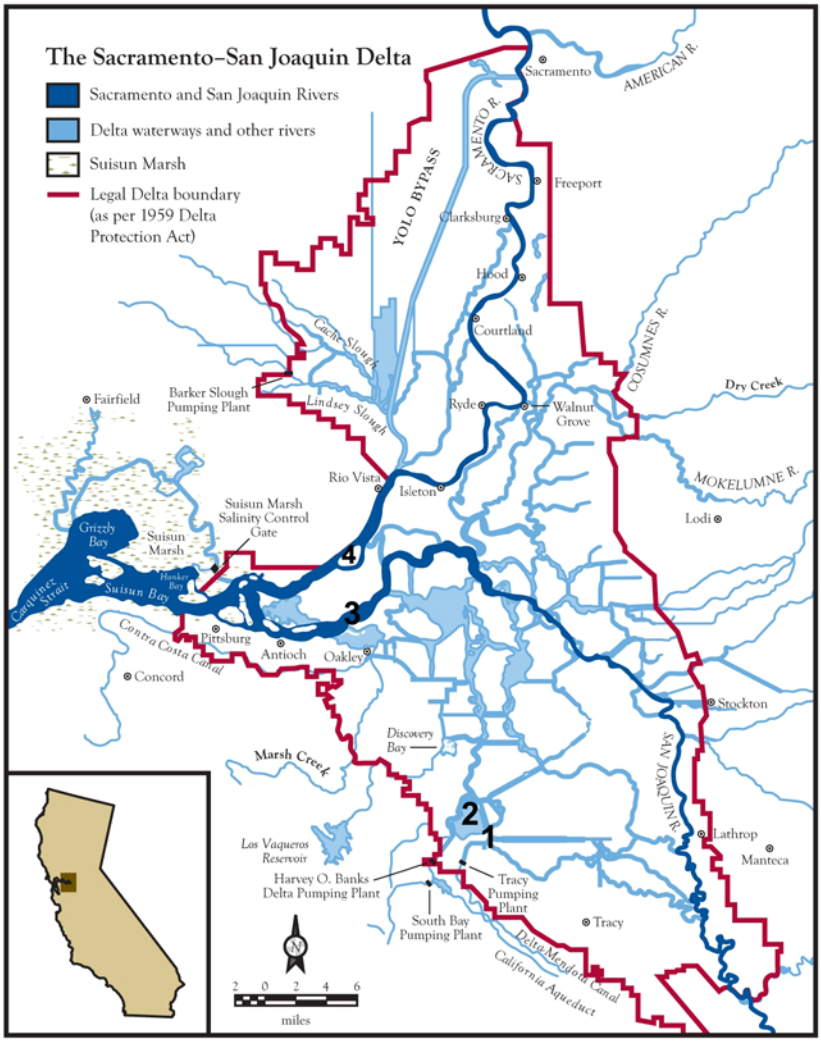

Figure 1. The Sacramento - San Joaquin Delta

1 Tracy Fish Collection Facility **2** Clifton Court **3** Antioch Release Site **4** Horseshoe Bend Release Site

where they encounter a double louver wall. Fish guided successfully by these louvers are diverted to one of four fish collection tanks. Although the louver/bypass components were designed to screen and salvage fish from exported flows, there are many potential areas where fish loss can occur, and the facility is reportedly not 100% effective (Karp *et al.* 1995; TFCF unpublished data).

Chinook salmon abundance is declining in the Delta due in part to non-native fish introductions and habitat alterations from long-term operations at JPP and California's Harvey O. Banks Pumping Plant (Moyle 2002; NMFS 2006, 2009). Recently, NMFS completed a biological opinion stating TFCF operations are likely to jeopardize the continued existence of the endangered Sacramento River winter-run Chinook salmon and threatened Central Valley spring-run Chinook salmon (NMFS 2009). Our objective is to determine facility survival (from the trash boom to the release sites) for juvenile Chinook salmon.

Problem Statement

Chinook salmon are declining in the Central Valley of California and two races are protected by the National Marine Fisheries Service (NMFS): winter and spring runs (NMFS 2005). Fall- and late-fall run Central Valley Chinook salmon are considered Species of Concern (NMFS 2005). Chinook salmon may be entrained at the TFCF from December through July, but the majority is entrained April and May (TFCF salvage data). Recently, NMFS determined operations of JPP may adversely affect the existence of the endangered winter-run and threatened Central Valley spring-run Chinook salmon (NMFS 2009). Our study will estimate TFCF survival for fall-run Chinook salmon as a surrogate for winter-run and spring run races.

Goals and Hypotheses

Goal:

1. Determine facility survival for juvenile (<175 mm fork length) Chinook salmon under normal operating and hydraulic conditions.

Hypothesis:

1. Facility survival (from trash boom to fish release) for juvenile Chinook salmon is 0%.

Materials and Methods

Fish Source and Care

Approximately 3,000 fall-run Chinook salmon (~50 mm fork length) from the Mokelumne River Fish Hatchery (Clements, California) were obtained in summer 2011. Fish will be held in flowthrough 750-L tanks, provided temperature-controlled ozonated, aerated well water (16°C), and fed Rangen soft moisture #1/#2 mix at ~4% body weight per d. Water quality (°C, pH, ammonia, and oxygen levels) will be monitored daily. Fish will be tempered at rates not exceeding 1°C/d to test temperatures (defined by water temperatures at the TFCF) by gradually exposing sturgeon to ozonated Delta water 14 d before testing.

Experimental Design

A review of past facility efficiency experiments, completed by a NMFS contracted scientist, suggests future efforts focus on determining overall facility survival/loss rather than focusing on specific components, *e.g*., louver efficiency (Andrew Jahn 2011, personal communication; Jeff Stuart 2011, personal communication). To comply with these recommendations, we propose to conduct release-recapture experiments, employing the use of acoustically tagged fish, to estimate facility loss for juvenile Chinook salmon (approximate size ~130–160 mm fork length) under normal facility operations. For this research, normal operations will be considered day-to-day operations (*e.g*., louver cleaning, hydraulic control, predator removals, etc.) conducted by TFCF operators as outlined in the TFCF Policy and Standard Operating Procedures or as directed by facility management. Our study plan will estimate loss from the TFCF trash boom to 100 m from the release pipe at both Horseshoe Bend (Emmaton) and Antioch release sites. The following study plan will partition the study into three subunits for clarification. These include determination of baseline Chinook salmon and

striped bass behavior upstream of the trashrack, survival evaluation from the trash boom to release sites, and determination of baseline Chinook salmon, striped bass, and Sacramento pikeminnow (*Ptychocheilus grandis)* behavior at the two release sites.

I. Determination of baseline Chinook salmon and striped bass behavior upstream of the trashrack

In order to acoustically distinguish juvenile Chinook salmon and predatory striped bass behavior in the vicinity of the TFCF, 10 hatchery juvenile Chinook salmon and 10 wild caught adult striped bass will be surgically implanted with an acoustic transmitter and released at the trash boom once each week for 4 weeks February–May and followed for 48 h or until the fish leave the detection area. This information will be used to distinguish 2-D acoustic tracks of juvenile Chinook salmon and striped bass and will allow us to determine if a tagged Chinook salmon was consumed by a striped bass in the study area. A series of four hydrophones upstream of the trash rack will be deployed in January, and maintained through the May (Figure 2).

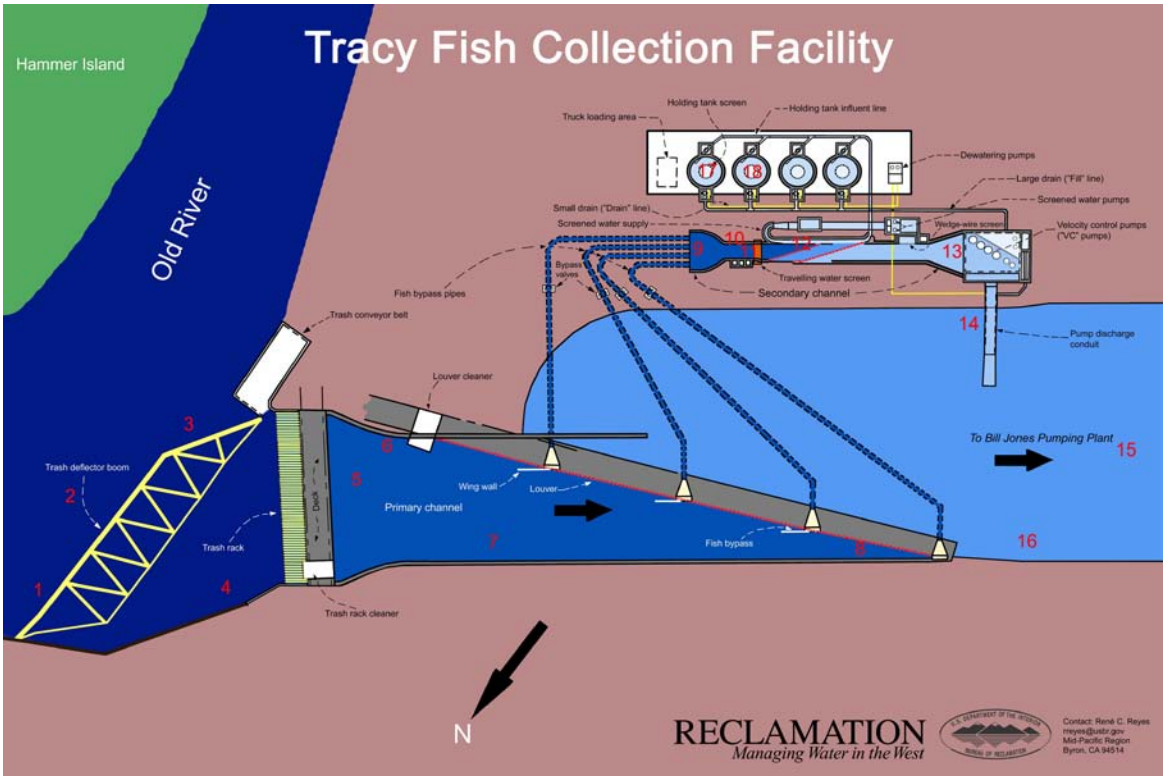

Figure 2.—Schematic of the Tracy Collection Fish Facility, Tracy California. Numbers in red indicate location of an acoustic hydrophone.

II. Determination of Chinook salmon loss from the trash boom to Delta release

Fish will be released on the downstream side of the trash boom at two evenly spaced locations and their movements tracked for a total of 16 replicates (four 4-d sets). Each replicate will include 10 releases, 5 d (8 am, 10 am, 12 pm, 2 pm, and 4 pm) and

5 night (8 pm, 10 pm 12 am, 2 am, and 4 am) to encompass temporal variations in fish behavior with varying flow and tidal conditions and the full range of normal operations that occur at the TFCF. For each release, six acoustically tagged fish will be transferred to three 18.9-L buckets (two fish/bucket), immediately transported to, and released at, the downstream side of the trash boom. A total of 60 experimental fish will be released each 24-h period. Total number of fish released per replicate was selected based on preliminary Chinook salmon efficiency data collected in March 2011. A determination of required sample size and number of replicates and a review of daily TFCF salvage estimates for Chinook salmon in February, March, April, and May 2008–2011 follows:

Using data from Chinook salmon experiments completed in March 2011 (mean WFE = 0.53), we require 38 fish (n)/release to get at least 20 fish into the holding tank/release. The following power curve (Figure 3) suggests a sample size of N=33 at the lowest power of 0.55 ($\alpha = 0.1$ and d, smallest difference desired to detect, = 0.1 or 10%).

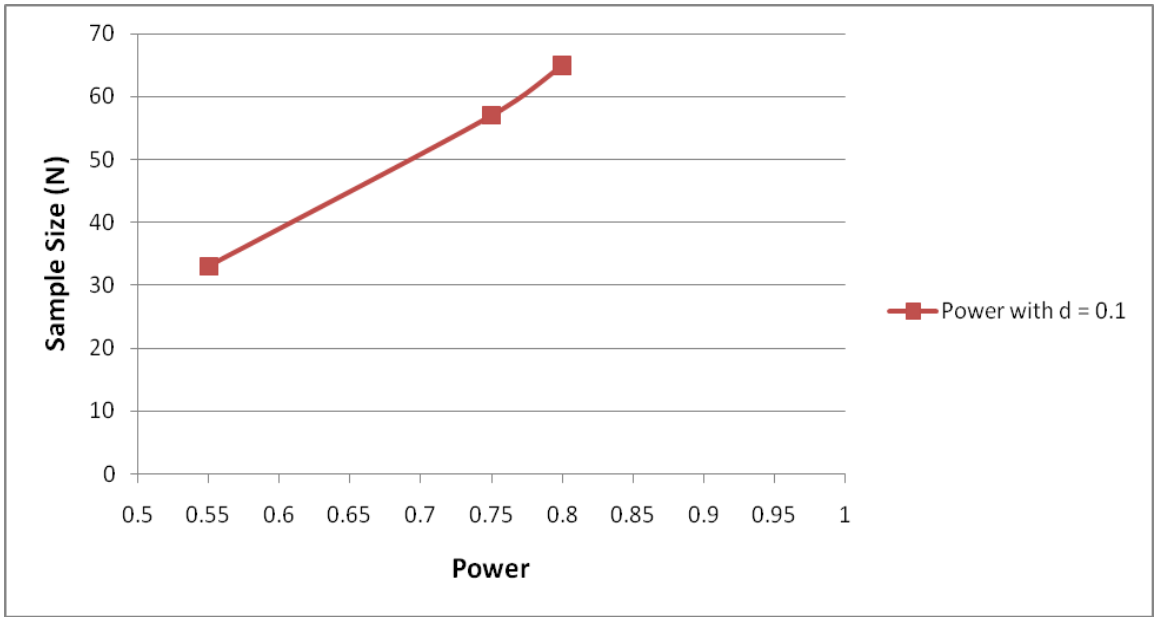

Figure 3.—Calculated sample size when d = 0.1 and power is varied from 0.55 to 0.8.

By varying d, Figure 4 suggests that a more realistic sample size of 16 is obtainable with d= 0.15 of 15%.

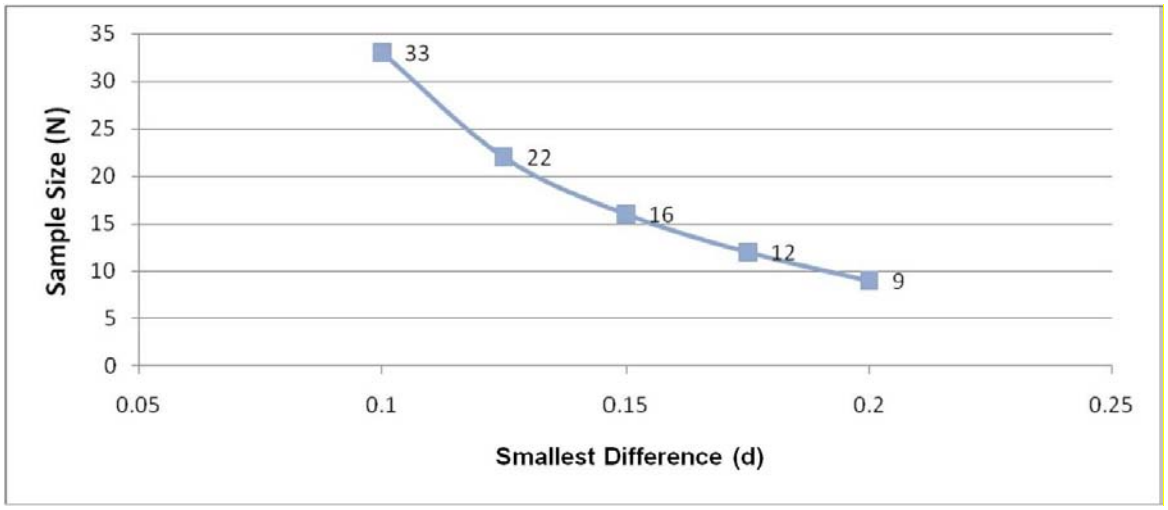

Figure 4.–Calculated sample size when d, the smallest difference it is desired to detect, is varied and power is 0.55 and α = 0.1.

In the spring, the collection tanks are typically drained every 8 h and all salvaged fish transferred for truck transport. Experimental fish will not be handled during this process. Prior to fish recovery for release to the Delta, the collection tanks will be partially drained and all striped bass (and other possible predators) examined for consumption of a tagged Chinook salmon in their gut. Fish salvage and fish movements (acoustic tagged fish) will be determined for 48 h following each release from the area upstream of the trash boom to the release sites. Hydraulic measurements [primary and secondary channel depths (m), primary and secondary velocity (m/s), water temperature (°C), water turbidity (NTU), number of JPP pumps in operation, and light level] will be collected every 2 h. Normal screen cleaning and predator removal operations, as well as any other potential losses of fish (*i.e.*, operator/researcher errors) will be recorded as they occur.

A series of 14 hydrophones within, and downstream of the TFCF (locations 5–18, Figure 2) will be used to acoustically track fish movements through the facility.

In order to acoustically distinguish juvenile Chinook salmon and predatory striped bass and Sacramento pikeminnow behavior, 10 juvenile Chinook salmon, 10 wild caught adult striped bass, and 10 wild caught adult Sacramento pikeminnow will be surgically implanted with an acoustic transmitter and released at both release sites (morning-Emmaton, night-Antioch) once each week for 4 weeks, February–May, and followed for 48 h or until the fish leave the detection area. This information will be used to distinguish 2-D acoustic tracks of the three species, and will allow us to determine if a tagged Chinook salmon was consumed by a striped bass or Sacramento pikeminnow within approximately 100 m of the release sites. A series of four hydrophones at each release site will be deployed in January and maintained through the May (Figures 5 and 6).

Figure 5.—Proposed layout of acoustic hydrophone system at the Antioch Bridge release site.

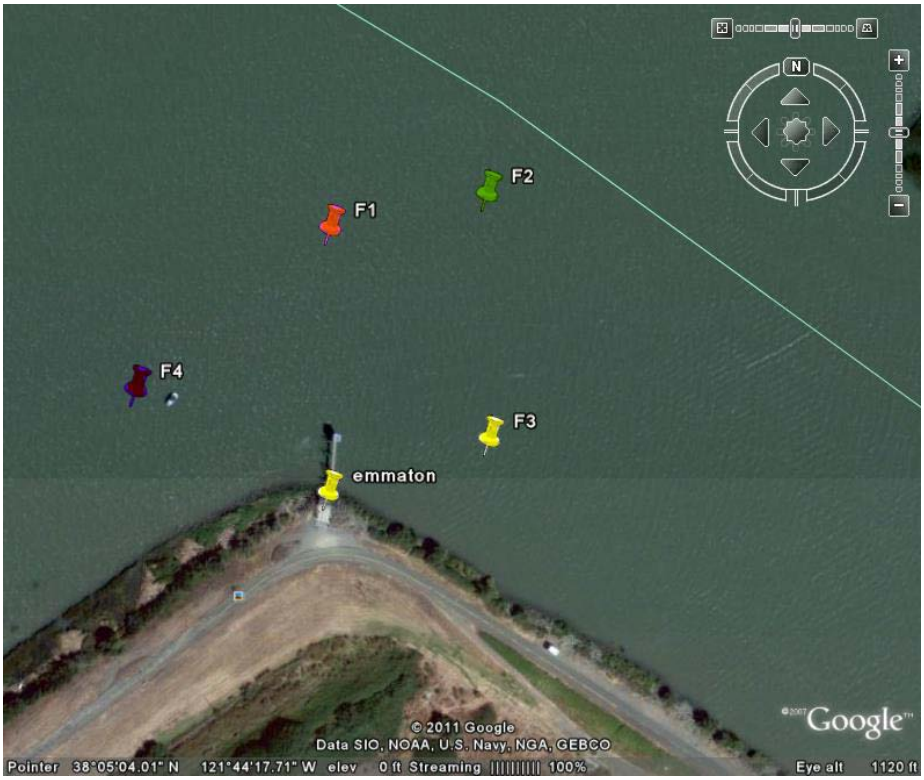

Figure 6.—Proposed layout of acoustic hydrophone system at the Emmaton release site.

III. Determination of baseline Chinook salmon, striped bass, and Sacramento pikeminnow behavior at Emmaton and Antioch release sites

Tag Implantation

One month prior to the experiment, the acoustic listening system (hydrophones and cables) will be installed, checked and any malfunctions fixed. One week prior to testing, experimental fish will be acclimated to ambient Delta temperatures using a mix of well and Delta waters (<2°C/day). Four days prior to testing, 100 Chinook salmon will be used to practice surgical transmitter insertion techniques. Fish will be anesthetized using a buffered solution of MS-222 (tricaine methanesulfonate; 150 mg/L), measured for weight (g) and fork length (mm), and a 12–13 mm medio-lateral incision will be made slightly anterior of the pelvic fin. Acoustic transmitters (HTI Model 795Lm microacoustic tag, 0.67 g weight in air, Hydroacoustic Technology Incorporated, Seattle, Washington) will be inserted into the abdominal cavity and the incision will be sutured with two knots using 3-0 Ethilon monofilament nylon and a FS-1 cutting needle closed. These fish will be observed for 72 h in ozonated Delta water for surgical complications before release (Anderson *et al*. 1997; Gingerich and Drottar 1989; Makiguchi and Ueda 2009). All experimental fish will be held for 3 d post surgery and acoustic transmitters checked prior to release. If a tag is not working or the behavior of a tagged fish appears abnormal (indicating stress or compromised health), a substitute fish will be used.

Data Analyses:

Data from acoustically tagged fish will be used to quantify non-participation, within facility predation, release site predation, through-louver passage, and in the following survival calculation.

C = number experimental fish leaving release site

T = total number experimental fish released at the trash boom

N = number non participants

Survival (S) = number acoustically tagged Chinook salmon to leave the release site/(number acoustically tagged Chinook salmon released at the trash boom minus the number of acoustically tagged Chinook salmon swimming upstream and away from the facility) S = C/(T-N)

Coordination and Collaboration

These studies will be coordinated with the California Department of Fish and Game's Delta diversion facilities reporting program, and the TFCF staff. All work will be reviewed by the Tracy Technical Advisory Team through progress updates on request and reviews of study plans and reports.

Endangered Species Concerns

Incidental "take" of ESA listed Chinook salmon is possible and such fish will be returned to Delta waters as quickly as possible. The total number of each ESA species incidentally caught or collected during the experiment will be recorded and sent to the

reporting agencies. The incidental take from this research is covered under the TFCF Section 10 permit.

Dissemination of Results (Deliverables and Outcomes)

We hope to collect all trials described above in FY12. If so, we will publish a summary draft report by species by September 30, 2012.

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